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PARASITIC COPEPODS ON THE FISHES OF THE GREAT BARRIER REEF, AUSTRALIA PART I. CYCLOPOIDA

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With Text-figures 1–10

Since the parasitic copepod fauna of the Great Barrier Reef, Australia is still largely unknown, we were very interested in the material sent to us from this region by Dr. K. Rohde, while director of the Heron Island Research Station. The collection consists of 200 vials of copepods recovered from about 70 species of fish.

The existing knowledge of the copepod parasites of fishes from the Great Barrier Reef is confined to the six species reported by Heegaard (1962) and nineteen species described by Kabata (1964, 1965a, 1965b, 1966a, 1966b, 1968a, 1968b). In this first part of our series dealing with the parasitic copepods of this region, new hosts and locality records are reported for two species: *Orbitacolax hapalogenyos* (Yamaguti & Yamasu) and *Anchistrotos moa* Lewis; and a new species of chondracanthid, which we propose to name *Pseudacanthocanthopsis rohdei,* is described. In addition, a female copepodid and a juvenile stage of *P. rohdei* are described together with a note on their metamorphosis.

A map (Fig. 1), showing the Great Barrier Reef and its various islands from which most of the collections were made, is included. Eagle Island is not identified in the figure, but it is located near Lizard Island. All type-specimens have been deposited in the United States National Museum, Washington, D. C. We would like to thank Dr. K. Rohde for his kindness and generosity in placing his collection of copepod parasites at our disposal.

Orbitacolax hapalogenyos (Yamaguti & Yamasu, 1959)

(Fig. 2)

Material Examined: One ovigerous female collected from the gills of *Lienardella fasciatus* on 3 December, 1973, from south reef of Heron Island.

Remarks: Yamaguti and Yamasu (1959) first described this species as *Taeniacanthus hapalogenyos* from the Inland Sea, Japan, where it was found attached on the gills and mouth cavity of *Hapalogenyos mucronatus.* Vervoort (1962) correctly transferred this species to the genus *Orbitacolax.* It appears that the present specimen (Fig. 2A)

is identifiable with *O. hapalogenyos*. However, there is a difference which exists between these two specimens, i.e. the Australian specimen possesses only two spinous setae on the terminal segment of the endopod of leg 4 (Fig. 2B), while the Japanese specimen has three. Since there is but one specimen, we can not determine whether this is an abnormality or geographical variation.

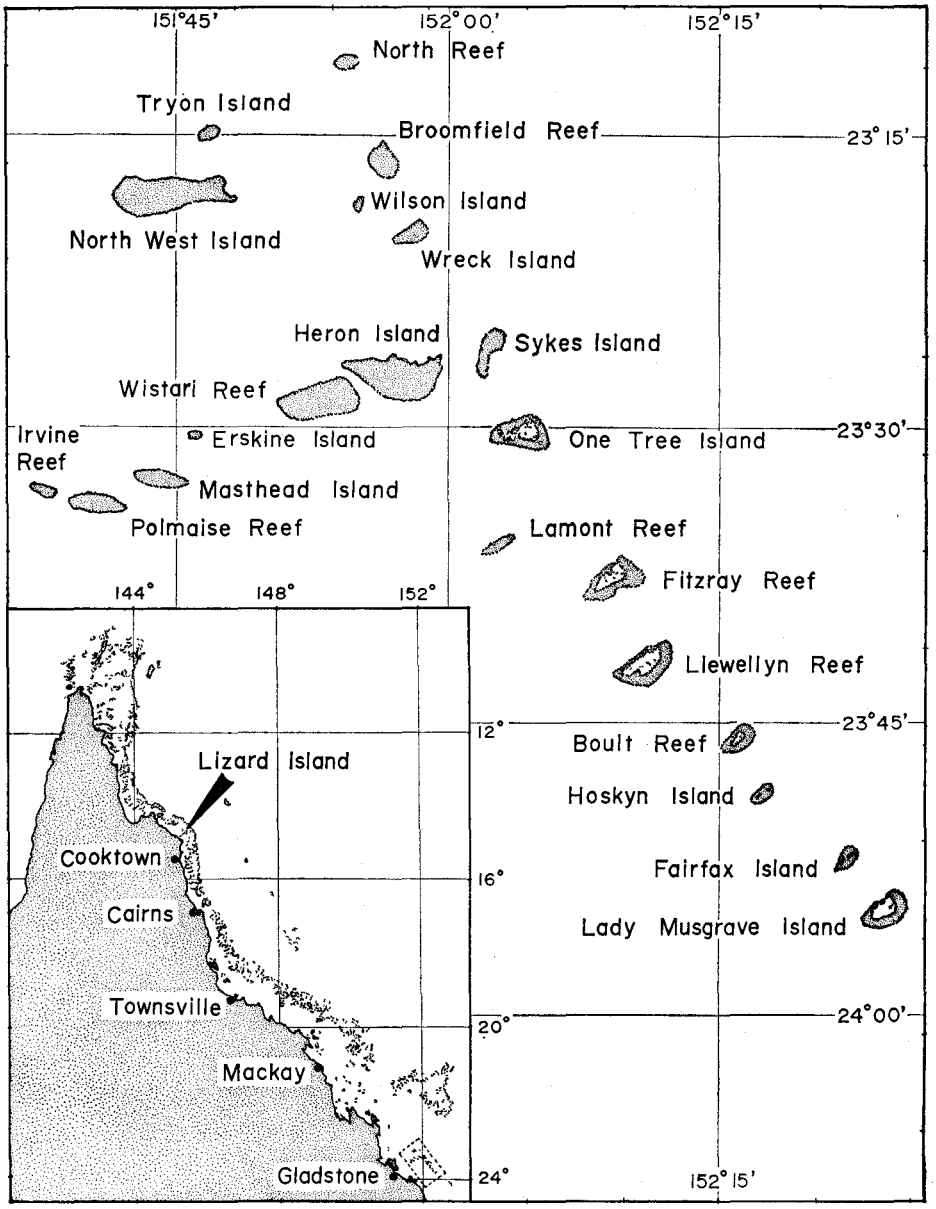

Fig. 1. Map of the Great Barrier Reef, Australia; with the southernmost part of the Reef (dotted rectangle) enlarged to show the islands from which most of the collections were made.

Anchistrotos moa Lewis, 1967

(Fig. 3)

Material Examined: Five females collected from the gills of *Ostracion tuberculatus* near Heron Island on 13 August, 1974.

Remarks: This species was first described by Lewis (1967) from *Ostracion lentiginosus* collected at Rabbit Island, Hawaii. The attachment site was not recorded.

Since this species was thoroughly described by Lewis (1967), a redescription seems unnecessary. Because of the difference in appearance of these copepods, due to their state of preservation, figures of two specimens (Figs. 3A, B) in different states are provided. There is, however, a major difference here. The Hawaiian specimen was figured as having three spinules on the distal end of the nodular swelling of the second segment of the maxilliped. The present specimen has no such spinules (Fig. 3C). The figure provided by Lewis does not show the curved nature of this nodular swelling. It is not known if this is an actual difference or if it is due to the view at which Lewis studied the maxilliped. The caudal rami were missing on all the specimens examined; therefore, they were not included in the figures.

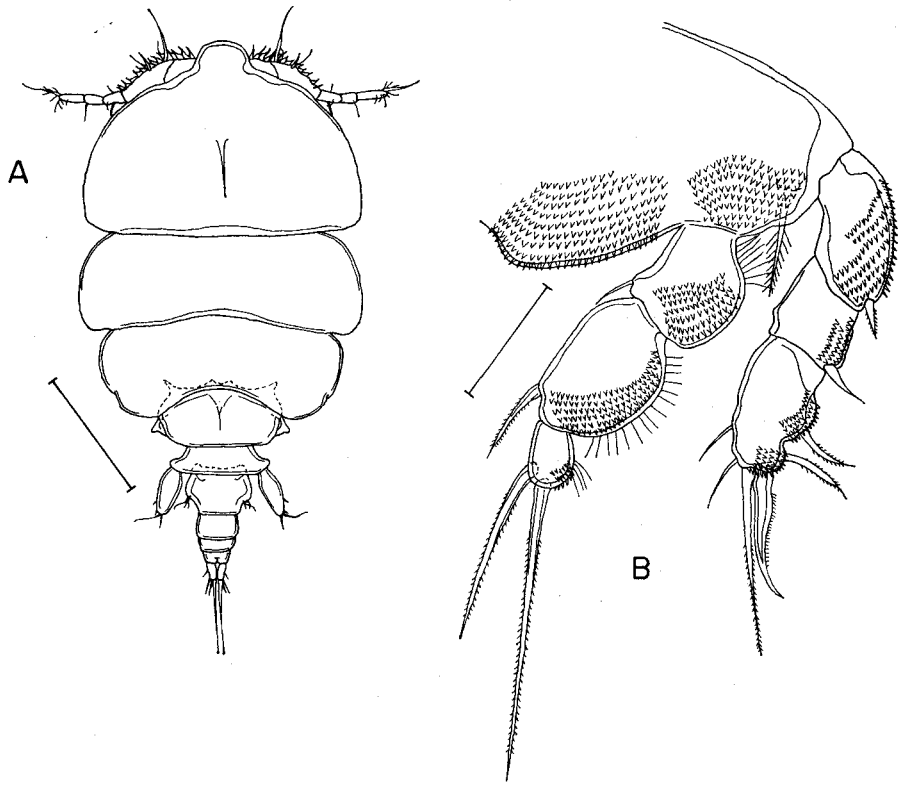

Fig. 2. *Orbitacolax hapalogenyos* (Yamaguti & Yamasu), female. A. body, dorsal. B. leg 4. Scale: 0.3 mm in A; 0.5 mm in B.

Pseudacanthocanthopsis rohdei n. sp.

(Figs. 4–10)

Material Examined: From gills of *Dascyllus reticulatus*: 3 ovigerous females all with males attached, from northeastern corner about 400 m off the main reef of Eagle Island, on 24 April, 1975; 1 ovigerous female with no male attached, from Lizard Island about 100 m off North Point, on 21 April, 1975. From gills of *Pomacentrus rhodonotus*: 1 ovigerous female with male attached; from reef crest on northwest side of Wreck Island, on 1 December, 1975; 1 copepodid and 1 juvenile female from Lizard Island about 100 m off N-Point, on 21 April, 1975; 2 ovigerous female with male detached, from Lizard Island in a "Lagoon" between Bird Island and airstrip, on 20 April, 1975; 3 young females without egg sac or male, from Lizard Island about 50 m west of the Station, on 20 April, 1975.

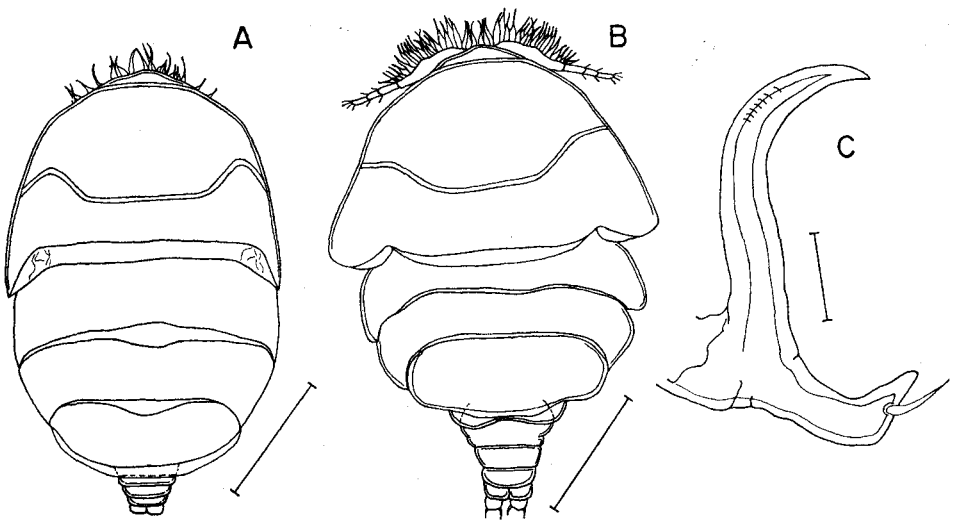

Fig. 3. *Anchistrotos moa* Lewis, female. A. body, dorsal. B. body, dorsal. C. terminal segment of maxilliped. Scale: 0.3 mm in A, B; 0.02 mm in C.

Female: The body (Figs. 4A, 8C, F) is rather short and stout. The head is distinctly longer than wide and consists of the cephalosome and the first pedigerous somite; it carries anteriorly a lobate ventrolateral process on each side. Both the first and second antennae protrude anteriorly well beyond the head (Fig. 8C). The ventral swelling, on which the mouth parts are located, possesses a short, blunt lobate process on its posterior margin on each side (Fig. 4A). The short neck is formed by the second pedigerous somite. The trunk is a little wider than long and is somewhat squarish in appearance. It bears a pair of short and blunt posterior processes. The genital segment (Fig. 4B) is about three times the length of the abdomen and possesses a pair of setules located ventrally; a pair of small processes are found at the junction between the trunk and the genital segment, to one of which the pygmy male attaches.

The abdomen (Fig. 4B) is indistinctly fused to the genital segment. The caudal ramus carries four small setae and one large, long terminal element. Egg sacs are almost as long as the body, with many rows of eggs.

The first antenna (Fig. 4C) is a fleshy, greatly swollen structure divisible into a

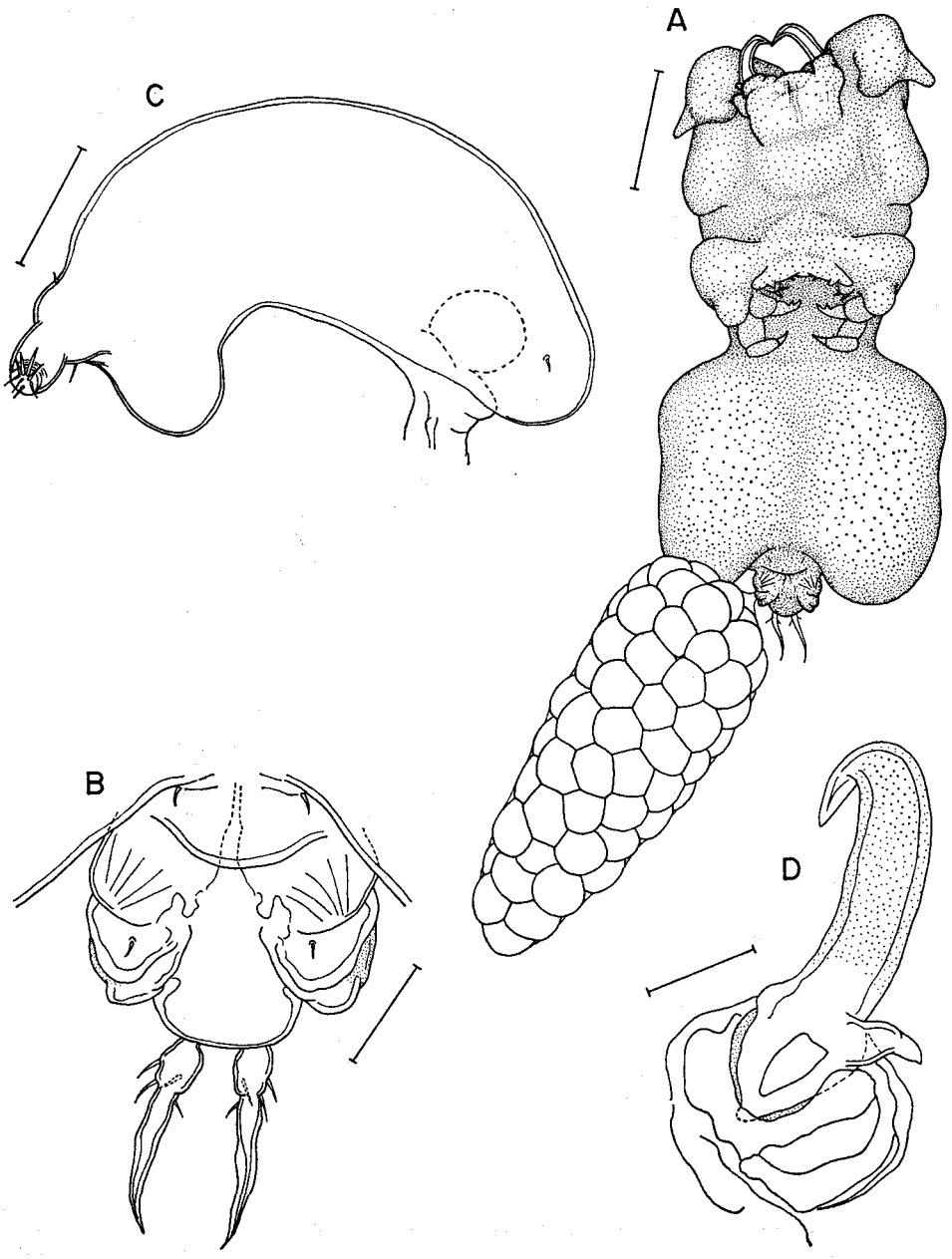

Fig. 4. *Pseudacanthocanthopsis rohdei* n. sp., female. A. body, ventral. B. genito-abdomen, ventral. C. first antenna. D. second antenna. Scale: 0.2 mm in A; 0.05 mm in B, C, D.

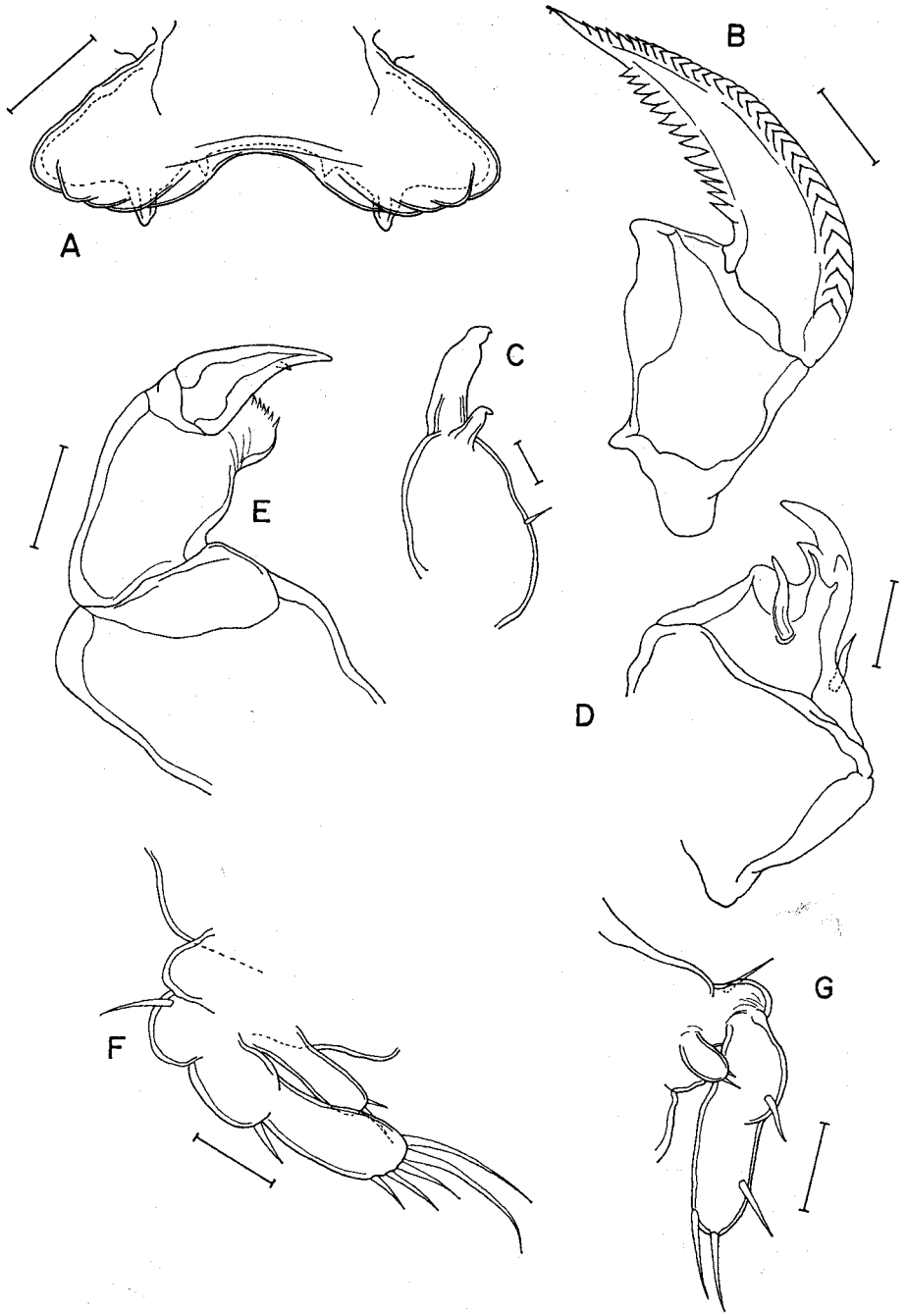

Fig. 5. *Pseudacanthocanthopsis rohdei* n. sp., female. A. labrum, anterior. B. mandible. C. first maxilla. D. second maxilla. E. maxilliped. F. leg 1. G. leg 2. Scale: 0.05 mm in A; 0.01 mm in B, C, F, G; 0.02 mm in D, E.

large, stout base; a small subterminal portion; and a smaller cylindrical terminal. In addition, the basal part has a spherical ventromedial lobe and a large protrusion on posterodistal corner. The armature is 1–2–8. The second antenna (Fig. 4D) is distinctly 2–segmented; the broad basal segment is unarmed and the terminal recurved claw carries an accessory antennule with no elements. The labrum (Fig. 5A) has a pair of papillae extending beyond the folded margin of the concave posterior surface and medially, a pair of smaller ones that do not protrude beyond this margin. The mandible (Fig. 5B) bears a row of 13 teeth on its concave side and 31 teeth on the convex side. The first maxilla (Fig. 5C) is a lobed structure possessing three extremely unequal elements. The second maxilla (Fig. 5D) is 2–segmented, with the distal segment bearing on its base a spiniform seta and a simple seta and on the distal process a hooklet and a tooth. The maxilliped (Fig. 5E) is 3–segmented; the unarmed first segment is the largest; the second is armed with a patch of spinules on the disto-inner surface; and the terminal segment is a short uncinate process bearing one small hooklet on its inner surface. Leg 1 (Fig. 5F) and leg 2 (Fig. 5G) are not only minute but also hidden in ventral view by the maxillipeds and can be easily overlooked. The two pairs of exopods are indistinctly 2–segmented, while the endopods consist of a single segment. Since the legs are small, the distinction between spines and setae was not possible. The first segment of both exopods are armed with one outer element; the second segment of the first exopod bears five terminal elements, while that of the second exopod possesses one outer and two terminal elements. The endopods of both legs are tipped with two elements.

Measurements: Body, 0.825–1.281 mm; head, 660×376 μm; genital segment, 103.8×131.6 μm; abdomen 42.3×65.8 μm; longest egg sac, 1.05 mm; egg, 118 μm.

Male: The body (Fig. 6A) measures 278×115 μm. The swollen cephalothorax is composed of the cephalosome and the first pedigerous segment. The metamerism on the body is distinct. The genital segment (Fig. 6B) possesses a pair of ventral ridges. The abdomen is wider than long, bearing a pair of small setules on the dorsal surface. The caudal ramus is armed with three small setae and one large, long terminal element.

The first antenna (Fig. 6C) is cylindrical and apparently divisible into two parts. The moderately enlarged basal portion carries eight elements, and the small terminal part bears eleven elements. One of the terminal elements is an aesthete, sharing a common stem with the longest terminal seta. The second antenna (Fig. 6D) is 2–segmented; the basal segment bears a small seta; the second segment is a recurved hook with two hyaline lobes and an accessory antennule tipped with three elements. The labrum (Fig. 6E) is markedly different from the female in not having the two pairs of papillae and the folded posterior margin. The mandible (Fig. 7A) bears a row of 9 teeth on the concave surface and a row of 11 teeth on the convex surface. The first maxilla (Fig. 7B) is much more slender and does not have the globose appearance that is found in the female; the armature is the same, although the two terminal elements in the male are not quite as stout. The second maxilla

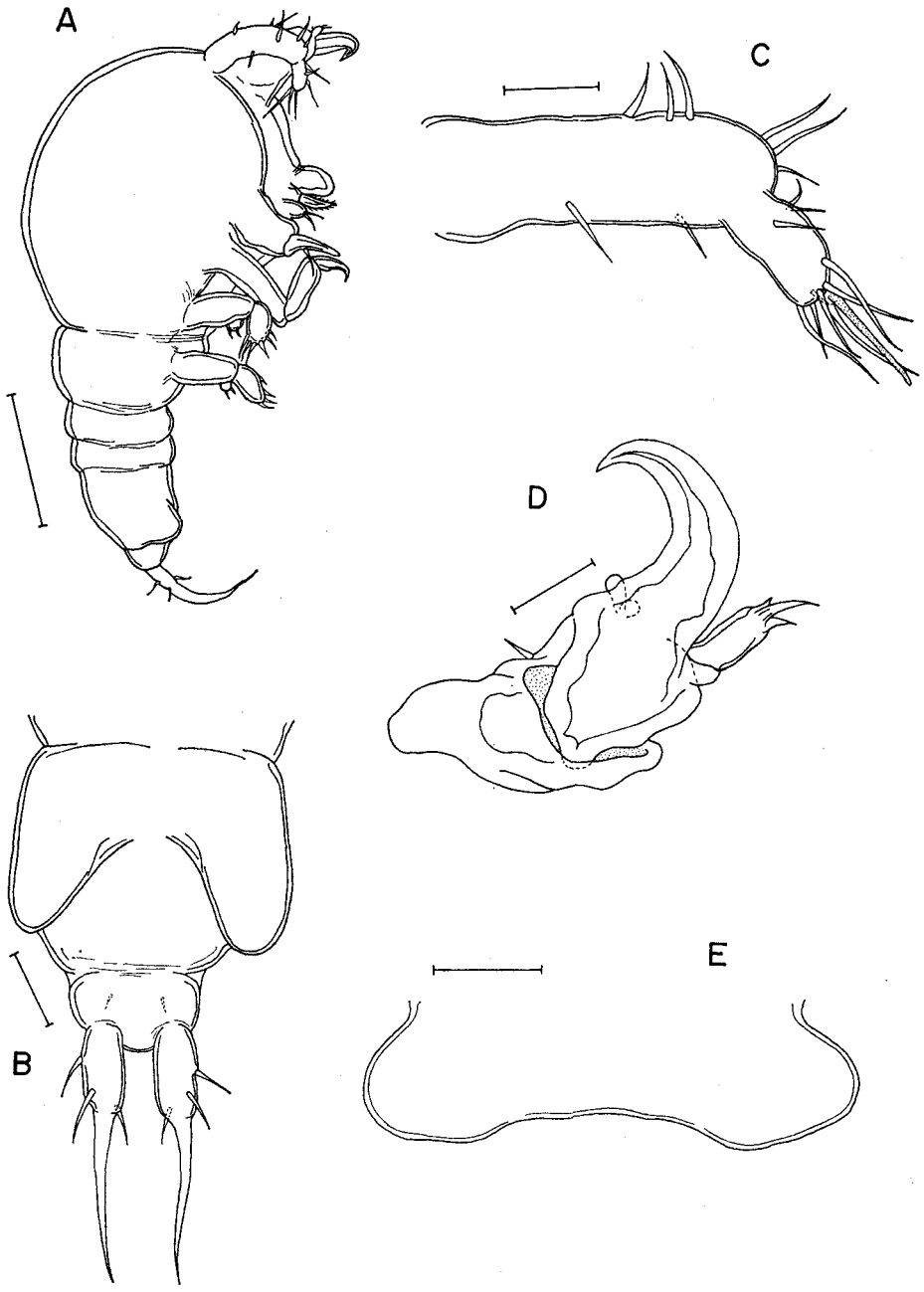

Fig. 6. *Pseudacanthocanthopsis rohdei* n. sp., male. A. body, lateral. B. genito-abdomen, ventral. C. first antenna. D. second antenna. E. labrum, anterior. Scale: 0.05 mm in A; 0.01 mm in B, C, D, E.

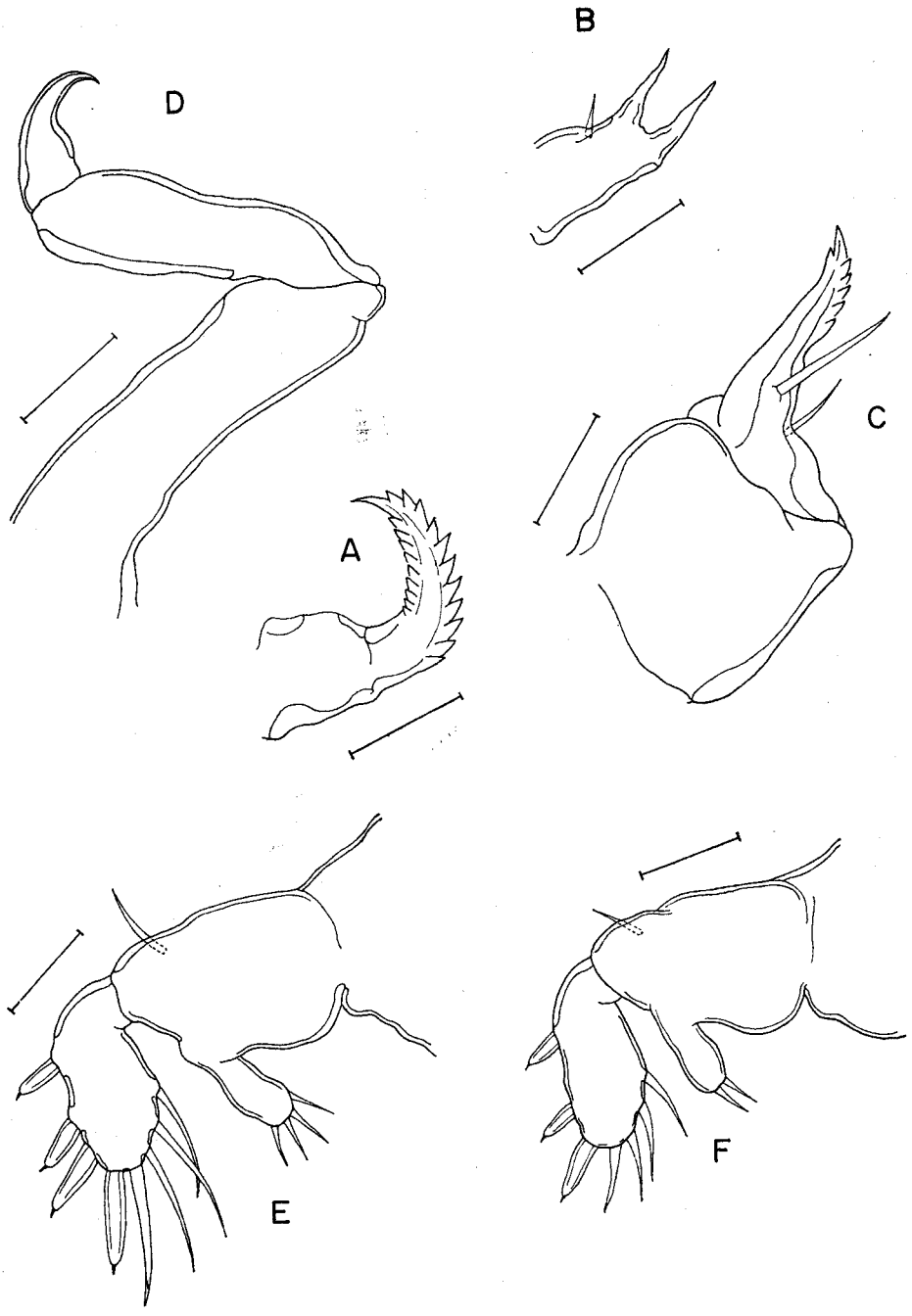

Fig. 7. *Pseudacanthocanthopsis rohdei* n. sp., male. A. mandible. B. first maxilla. C. second maxilla. D. maxilliped. E. leg 1. F. leg 2. Scale: 0.01 mm in all drawings.

(Fig. 7C) is 2-segmented; the terminal segment bears two unequal proximal setae, one tooth on the anterior margin, and five teeth on the posterior margin. The maxilliped (Fig. 7D) is very different from the female; the first and the second segments are elongate and rather slender without armature; the terminal segment is a simple recurved claw without hooklet. Leg 1 (Fig. 7E) and leg 2 (Fig. 7F) are biramous, each rami consisting of only one segment. The formula is as follows (Roman numerals indicate spines and Arabic numerals, setae):

Leg 1	Prop 1–0	exp IV–4
		enp 4
Leg 2	Prop 1–0	exp III–4
		enp 2

Each spine on the exopod of both legs bears one small flagellum at its tip.

Copepodid Female: The body (Figs. 8A, D) is relatively slender, measuring 381 $\times$97 μm. The cephalosome is longer than wide and moderately swollen. The metamerism on the body is distinct. There are no distinguishing features on either the genital segment (Fig. 9A) or the abdomen; both are wider than long. The caudal ramus bears three small setae and one large terminal element carrying an inner seta at the base.

The first antenna (Fig. 9B) is similar to the male; however, in the copepodid female the terminal cylindrical portion is indistinctly 3-segmented; the armature is 7–2–2–8. As in the male, the aesthete, one of the eight elements of the last segment, shares a common stem with the longest seta. The 3-segmented second antenna (Fig. 9C) is proportionately large and is undoubtedly an effective prehensile structure; the basal segment is stout and unarmed; the second segment is somewhat angular with a small seta on its inner margin; and the terminal segment is a strongly recurved claw bearing two hyaline lobes (like the male) and an accessory antennule tipped with two elements. The labrum (Fig. 9D) resembles the male in having a smooth posterior margin without papillae. The mandible (Fig. 9E) bears the same number of teeth (13) on the concave side as the adult female, but has only 19 teeth on the convex side. The first maxilla (Fig. 9F) is similar to the adult female, but is more irregular in shape, with the two terminal elements not as stout. The second maxilla (Fig. 9G) is 2-segmented with the terminal segment bearing nine small teeth and two elements. The maxilliped (Fig. 10A) is like the male, except for the presence of a small hooklet. The two pairs of legs (Figs. 10B, C) are biramous and are almost identical to the male except for the absence of the setae on both protopods, the presence of hairs on the inner margin of the exopod of leg, 1 and the distinct 2-segmented condition of the exopod of leg 1.

Juvenile Female: The body (Figs. 8B, E), measuring 611 $\times$ 273 μm, is comprised mostly of the head (about one half the total length), which is approximately twice the width of the largest portion of the trunk. The head possesses an anterior protrusion (Fig. 8E) and the developing ventrolateral lobes. The first antenna, second antenna, and the mouth parts are very large in comparison to the body size (Fig.

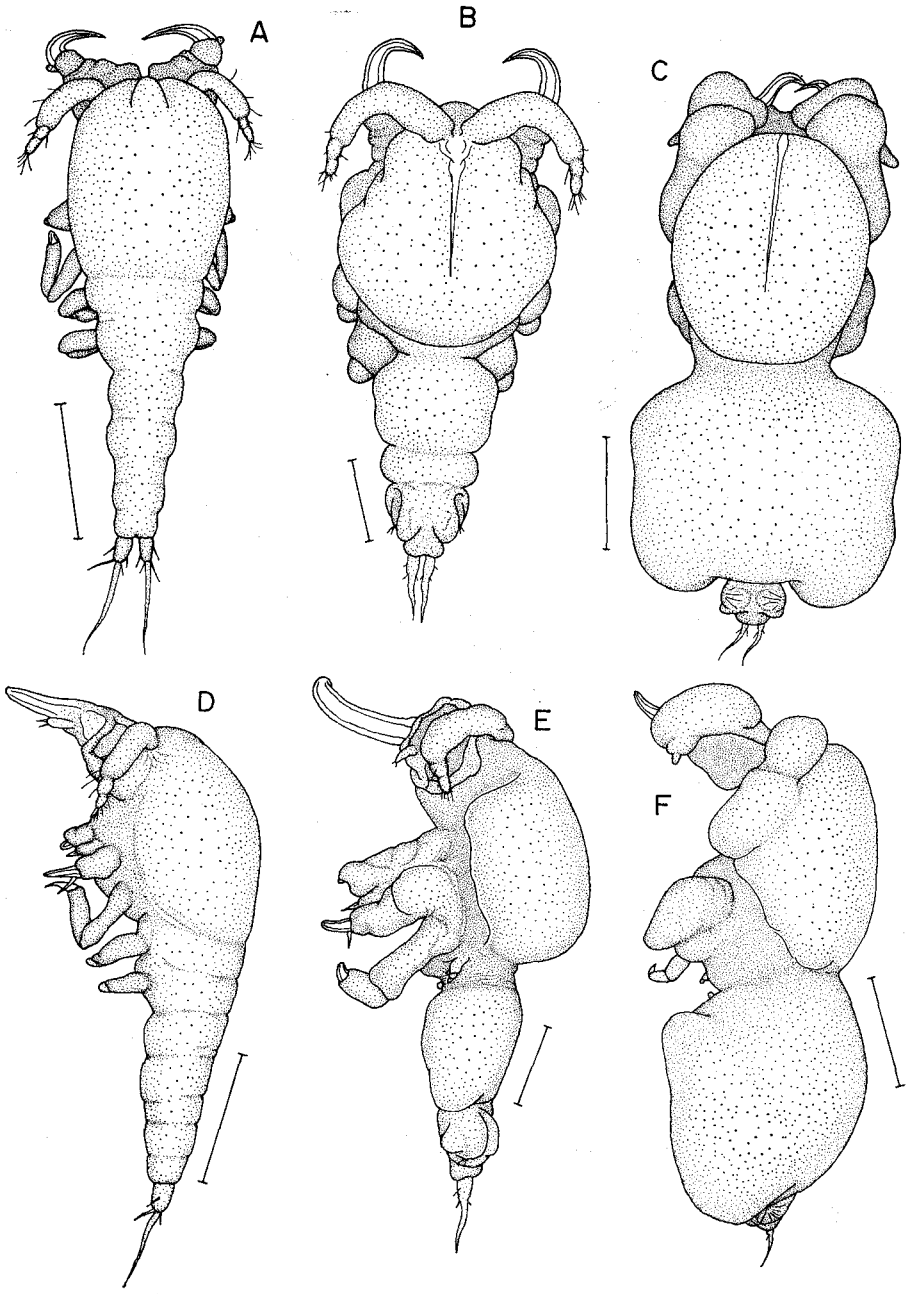

Fig. 8. *Pseudacanthocanthopsis rohdei* n. sp., female. A. copepodid, dorsal. B. juvenile, dorsal. C. adult, dorsal. D. copepodid, lateral. E. juvenile, lateral. F. adult, lateral. Scale: 0.1 mm in A, B, D, E; 0.2 mm in C, F.

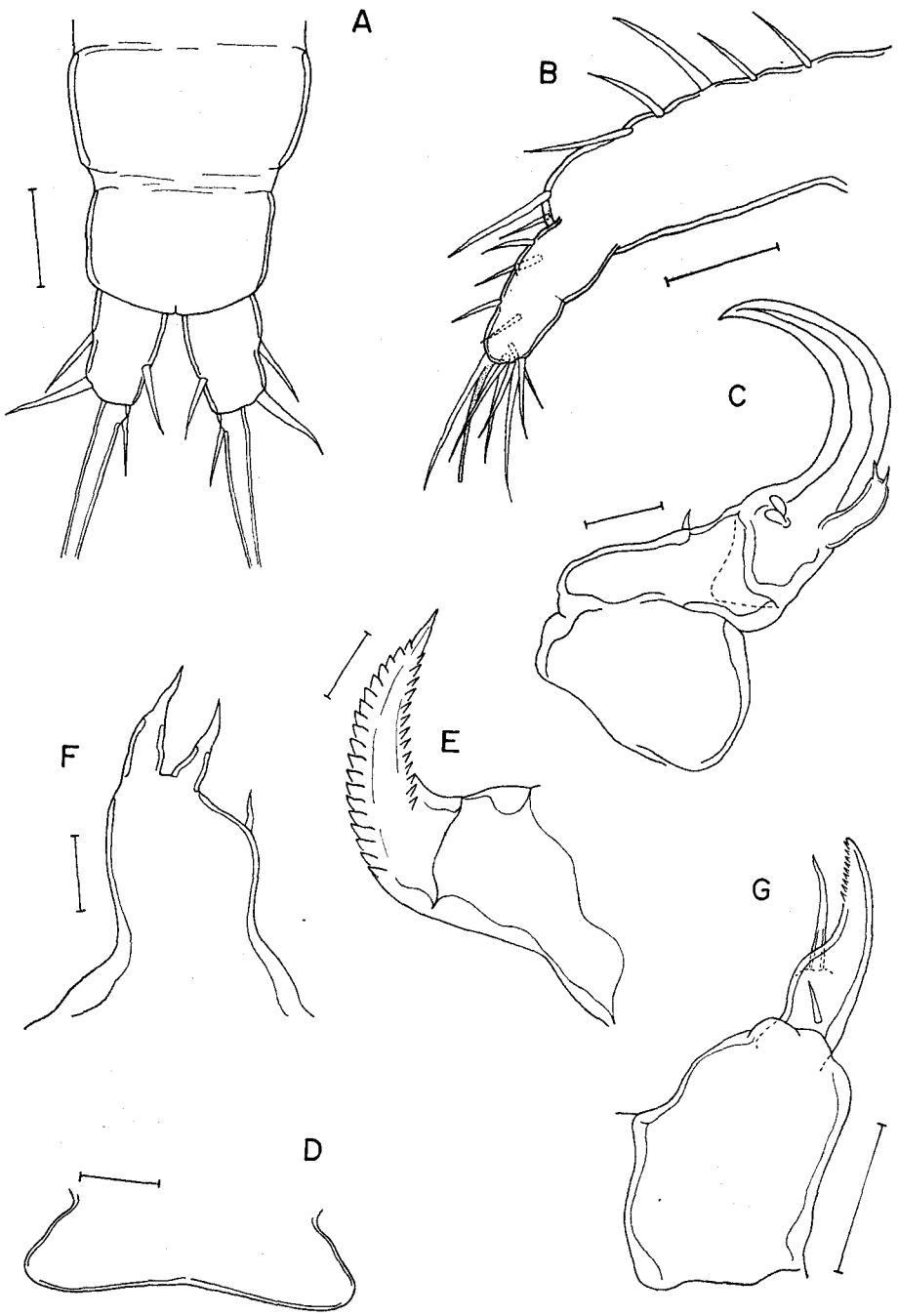

Fig. 9. *Pseudacanthocanthopsis rohdei* n. sp., copepodid female. A. genito-abdomen, ventral. B. first antenna. C. second antenna. D. labrum, anterior. E. mandible. F. first maxilla. G. second maxilla. Scale: 0.03 mm in A, B, C, D, G; 0.01 mm in E. F.

8E). Although it is difficult to ascertain, it appears that the short neck is formed by the second pedigerous somite. The third pedigerous somite seems to contribute more to the formation of the trunk than the fourth somite. The genital segment (Fig. 10D) and the abdomen taper posteriorly. The genital segment (Fig. 10E) carries the egg sac attachment area dorsolaterally and leg 6, which is represented by two setae. The abdomen, which is about one third the length of the genital segment and about one half the width, bears two small setules dorsally. The caudal ramus (Fig. 10D) is similar to the ovigerous female.

The posteriorly curved, cylindrical first antenna (Fig. 10F) is 3-segmented, narrowing in the last two segments and covered with a transparent membrane in the basal segment. The first segment has six setae, the second carries one seta, and the terminal segment bears eight setae. The accessory antennule on the second antenna has developed into a process closely resembling that of the ovigerous female; except it still retains two elements at the tip. All other appendages are identical in appearance to the ovigerous adult.

Remarks: Previous to the discovery of the present species, there were only three species of *Pseudacanthocanthopsis* known. They are *P. apogonis* Yamaguti & Yamasu, 1959; *P. secunda* Yamaguti & Yamasu, 1960; and *P. bicornutus* (Shiino, 1960). All were recorded from Japan.

P. rohdei can be easily distinguished from *P. apogonis* and *P. secunda* in having both legs biramous and non-lobate and a greatly swollen first antenna (as opposed to cylindrical). The second maxilla is unusual in possessing an accessory hooklet and only one tooth. This appendage, unfortunately, can not be used as a distinguishing feature, because it was not dissected and studied in detail by Yamaguti and Yamasu (1960) nor Izawa (1975).

The overall morphology of *P. rohdei* is very similar to *P. bicornutus*. However, the Australian species is different from the Japanese species in having a much enlarged first antenna and more powerful second antenna.

The accessory antennule on the female second antenna was not mentioned by Shiino (1960) for *P. bicornutus* nor by Yamaguti and Yamasu (1960) for *P. secunda*. Although in his revision of the chondracanthid genera Ho (1970) stated that only the male of *Pseudacanthocanthopsis* has an accessory antennule, it seems that the female also has it. The type-species, *P. apogonis* was described by Yamaguti and Yamasu (1959) as lacking an accessory antennule in the female, but Izawa's (1975) redescription clearly showed its presence. Since the Australian species also has this structure, it is presumed that it was overlooked in *P. bicornutus* and *P. secunda*.

Notes on Metamorphosis of *P. rohdei*

Chondracanthids are one of the several families of parasitic copepods that include a process of metamorphosis in the maturation development of the female. Although a complete life history is known in some species of copepod families with metamorphosis, e.g. Lernaeidae, Lernaeoceridae, and Lernaeopodidae, nothing is known in

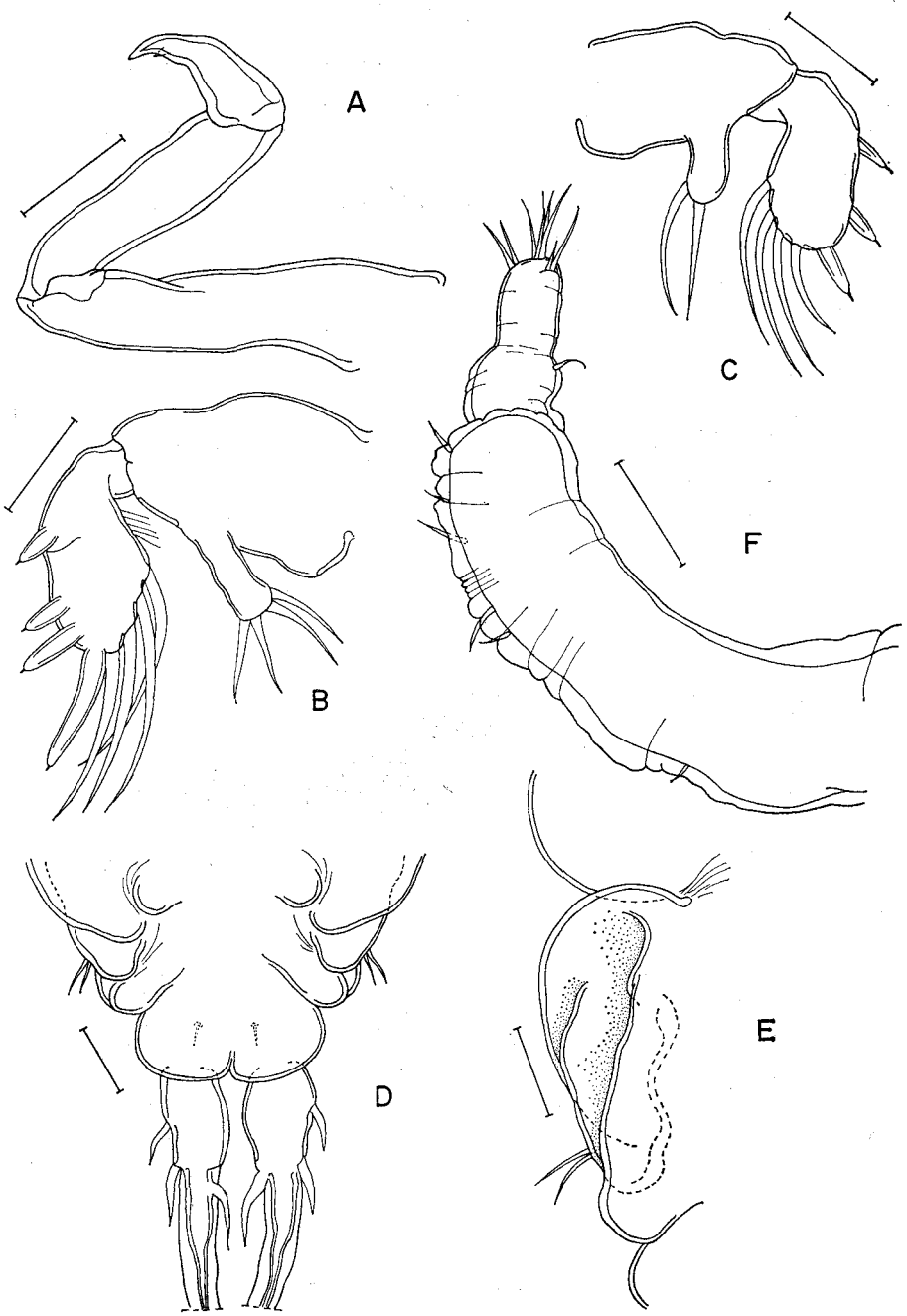

Fig. 10. *Pseudacanthocanthopsis rohdei* n. sp., copepodid female and juvenile female. Copepodid female: A. maxilliped; B. leg 1; C. leg 2. Juvenile female: D. genito-abdomen, ventral; E. genital segment, dorsal; F. first antenna. Scale: 0.03 mm in A, B, C, D, E; 0.05 mm in F.

the Chondracanthidae. Therefore, the discovery of a copepodid female and a metamorphosing juvenile female in the present material necessitates special attention.

Although Hansen (1923), Heegaard (1947), Pillai (1964), Kabata (1969) and Ho (1972) have reported copepodid stages of certain chondracanthid species, they are male copepodids that were found attached to an adult or a juvenile female. The female copepodid recovered on the gill of *Pomacentrus rhodonotus* from the Great Barrier Reef is the first one known. It is determined as a female because it is larger than the adult male and lacks the ventral ridges on the genital segment.

During the metamorphosis of *P. rohdei*, there are five trends that are apparent: (1) increase in size, (2) reduction of certain body parts, (3) reduction in number of elements (setae, spines, etc.), (4) fusion of somites, and (5) development of body processes.

The copepodid female (Fig. 8A) has a typical cyclopoid shape, measuring 381×97 μm, with the cephalothorax about one third the total length and no signs of the ventrolateral processes. The juvenile female (Fig. 8B) has increased in size (611×273 μm) along with a partial development of the ventrolateral processes. In the ovigerous female (Fig. 8C) the head has enlarged to include the first pedigerous somite and become half the total length; also, the development of the ventrolateral processes is complete.

The narrow, elongate trunk of the copepodid, measuring 129×78 μm, consists of six relatively distinct somites, In the juvenile, the first pedigerous somite has fused with the cephalothorax; the second pedigerous somites has reduced to a short neck; and the third and fourth pedigerous somites have fused to form the trunk, which has a pair of developing posterior processes. In addition, the trunk has increased in size measuring 165×151 μm. In the adult, the trunk has become squarish in appearance. There has also been a corresponding increase in the size of the posterior processes. The genital and abdominal segments in the copepodid are about equal in size; with the former measuring 26×42 μm and the latter, 24×37 μm. The genital segment has increased nearly three times in size in the juvenile, measuring 75×108 μm; in addition, the egg sac attachment area has appeared; while the abdomen, remaining about the same size, has fused with the genital segment. The formation of the pair of small processes (to which the pygmy male attaches) at the junction of the trunk and the genital segment does not occur until after the juvenile stage.

It seems unusual that the copepodid has five elements on the caudal ramus; the juvenile, only four; and the ovigerous female, five again (cf. Figs. 9A, 10D, 4B). However, it is interpreted that both inner setae in the juvenile were broken off in the process of handling.

In the copepodid stage, the mouth parts, which are located on a swelling, protrude a little beyond the head (Fig. 8D); the swelling increases in size until the mouth parts extend ventrally beyond the head in the ovigerous female. The ventral processes, adjacent to the mouth parts, are not seen until the juvenile stage (Fig. 8E); they become a fairly large lobe in the ovigerous female (Fig. 8F).

There is an increase in size and degree of globosity of the first antenna, with a reduction in number and relative length of the setae from the copepodid stage to the ovigerous female. The second antenna increases in size and looses the two hyaline processes at the base of the terminal claw. The first and the second segments in the copepodid fuse to form the broad basal segment in the adult. The two apical elements on the accessory antennule of the second antennae are eventually lost in the adult. Most of the modifications of the mouth parts and legs occur during the metamorphosis from the copepodid to the juvenile stages. The labrum in the juvenile has already developed folds and two pairs of papillae on the posterior margin. The number of teeth on the convex side of the mandible in the juvenile has increased to the number found in the ovigerous female. The first maxilla does not undergo extensive changes throughout its development. The second maxilla in the juvenile has become stouter; the number of teeth reduced; and the accessory hooklet formed. The maxillipeds undergo the most drastic modifications, from an elongate, slender structure in the copepodid (Fig. 10A) to a stout one with a spinous protrusion in the juvenile and adult (Fig. 5E). Both pairs of legs in the juvenile have already become greatly reduced in size, and in number of elements with a complete loss of the flagellated stout spines.

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